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Flexion and Rotation of the Trunk and Lifting at Work Are Risk Factors for Low Back Pain

Results of a Prospective Cohort Study

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Study Design. A 3-year prospective cohort study among workers of 34 companies in the Netherlands.

Objectives. To investigate the relation between flexion and rotation of the trunk and lifting at work and the occurrence of low back pain.

Summary of Background Data. Previous studies on work-related physical risk factors for low back pain either lacked quantification of the physical load or did not take confounding by individual and psychosocial factors into account.

Methods. The study population consisted of 861 workers with no low back pain at baseline and complete data on the occurrence of low back pain during the 3-year follow-up period. Physical load at work was assessed by means of analyses of video-recordings. Information on other risk factors and the occurrence of low back pain was obtained by means of self-administered questionnaires.

Results. An increased risk of low back pain was observed for workers who worked with the trunk in a minimum of 60° of flexion for more than 5% of the working time (RR 1.5, 95% CI 1.0–2.1), for workers who worked with the trunk in a minimum of 30° of rotation for more than 10% of the working time (RR 1.3, 95% CI 0.9–1.9), and for workers who lifted a load of at least 25 kg more than 15 times per working day (RR 1.6, 95% CI 1.1–2.3).

Conclusions. Flexion and rotation of the trunk and lifting at work are moderate risk factors for low back pain, especially at greater levels of exposure. [Key words: cohort studies, lifting, low back pain, posture, risk factors, videotape recording, workplace] **Spine 2000;25:3087–3092**

The effect of physical load at work on the occurrence of low back pain has been studied extensively during the past 20 years. Several reviews of the literature have reported that there is evidence that flexion and rotation of the trunk and lifting at work are risk factors for back pain.[2,6,11]

Although a number of articles have addressed the limited value of self-reported physical workload,[23,24] to date only two case-referent studies actually have quantified physical load at work.[17,18] Unfortunately, potential confounding by psychosocial work characteristics was not taken into account in the reported analyses of the data of these studies.[17,18] Most previous studies on the risk of work-related physical factors failed to assess and include in the analyses individual and psychosocial factors that also may be relevant in the etiology of low back pain.[8] The Boeing study was the first long-term prospective cohort study that included physical, psychosocial, and individual factors.[3,4]

The present report on low back pain is part of the Study on Musculoskeletal disorders, Absenteeism, Stress, and Health (SMASH), a prospective cohort study among a working population that was initiated to identify risk factors for musculoskeletal disorders. The objective of the analyses described in this article was to determine whether flexion and rotation of the trunk and lifting at work are risk factors for the occurrence of low back pain and to explore the exposure–response relation of these work-related physical factors with low back pain.

Materials and Methods

Workers were recruited from 34 companies located throughout the Netherlands. The participating companies were asked to select workers who had been employed in their current job for at least 1 year and who were working 24 hours per week or more. Workers in blue-collar jobs as well as workers in white-collar jobs and caring professions were included in the study. The baseline measurements were carried out between March 1994 and March 1995 and consisted of three aspects: a self-administered questionnaire, assessment of the physical load at the workplace, and a physical examination. There was a 3-year follow-up period.

At baseline, 1789 (87%) of the 2064 workers who were invited to participate completed the questionnaire, 1738 of whom were eligible for participation in the study on risk factors for low back pain. Thirty workers were excluded because they had not been employed in their current job for at least 1 year or had a working week of less than 20 hours and therefore did not meet the inclusion criteria. A further 17 workers were excluded because they had another paid job for a substantial number of hours in addition to the job at the company from which they had been recruited, and 4 workers were excluded because they had had a work disability due to low back pain in the previous 12 months. For the longitudinal analysis described here, a subcohort of 1192 workers with no low back pain at baseline was identified: workers who reported at baseline that they had not had regular or prolonged low back pain in the previous 12 months.

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Data Collection. All risk factors included in the analyses were measured at baseline. The physical load at work was assessed by means of video-recordings and force measurements at the workplace, according to a standard protocol.* Four video-recordings of all workers were made randomly during the course of 1 day. The duration of each video-recording was 10–14 minutes, depending on the variability of the worker's tasks. The project assistants who made the video-recordings classified all workers into groups with similar tasks and a similar physical load. Within each group, analyses of the posture, movement, and force exertion of one in four workers were made by means of observations from the video-recordings. The mean values for flexion and rotation of the trunk and lifting and sitting postures of the workers in each group for whom the video-recordings were analyzed were assigned to all workers in the same group.

Assessment of the percentage of the working time spent in a sitting position and of the percentage of the working time spent with the trunk in a minimum of 30° or 60° of flexion was based on continuous observations from the video-recordings. The categories of trunk flexion that were observed were defined as neutral (<30 degrees), mild flexion (30–60 degrees), extreme flexion (60–90 degrees), and very extreme flexion (>90 degrees). Assessment of the percentage of the working time spent with the trunk in rotation was based on multimoment observations from the four video-recordings per individual. The categories of trunk rotation were defined as neutral (<30°) and twisting (>30°) and were observed every 15 seconds. Assessment of the number of times workers lifted a load of any weight, or a load of at least 10 or 25 kg during a working day, was based on continuous observations from the video-recordings and on force measurements made at the workplace. The number of lifts during the period observed (four times 10 or 14 minutes) was extrapolated to the number of lifts for an 8-hour working day.

Individual factors such as age, gender, level of education, and smoking habits were assessed on the basis of certain items in the self-administered questionnaire. One question was included for the assessment of exercise behavior during leisure time.[9] Psychosocial work characteristics were measured by means of a Dutch version of Karasek's Job Content Questionnaire and concerned the dimensions quantitative job demands, decision authority, skill discretion, supervisor support, and coworker support.[14] The psychometric properties and the construction of the scales for these dimensions have been described by De Jonge et al[13] for the data from the present study. Job security was assessed on the basis of one single question.[14] Driving a vehicle at work and during leisure time, as well as frequent flexion and/or rotation of the upper part of the body and moving heavy loads (>25 kg) during leisure time, were assessed by means of the Loquest questionnaire.[10] Assessment of the body mass index was based on measurements of weight and height taken by a physiotherapist during the physical examination at baseline.

After each year of the follow-up period, the occurrence of low back pain and of workplace changes was assessed by means of a postal questionnaire. In the baseline and follow-up questionnaires, assessment of the occurrence of low back pain was based on an adaptation of the Nordic Questionnaire.[15] Cases of low back pain were defined for those workers who reported in at least one of the annual self-administered follow-up questionnaires that they had had regular or prolonged low back pain in the previous 12 months.

*Available on request from the first author (in Dutch).

Statistical Analysis. Univariate analyses were performed with the computer package Epi Info (Version 6.0). In these analyses, relative risks (RR) and corresponding 95% confidence intervals (95% CI) were calculated for the potential risk factors flexion and rotation of the trunk and lifting at work by comparing the cumulative incidence of low back pain between groups with different levels of exposure. The variables age, gender, smoking habits, body mass index, exercise behavior during leisure time, quantitative job demands, decision authority, skill discretion, supervisor support, coworker support, job security, moving heavy loads during leisure time, frequent flexion and/or rotation of the upper part of the body during leisure time, driving a vehicle during leisure time and at work, and the percentage of the working time spent in a sitting position were considered to be potential confounders. Therefore, it was checked whether these variables were actually univariately associated with the occurrence of low back pain with a Yates' corrected P value of less than 0.25.[1,12] Variables that met this criterion were included in the multivariable analyses. Age and gender were included in the multivariable analyses, however, irrespective of the association with low back pain found in univariate analyses of this data set. In the univariate analyses, continuous independent variables were recoded as categorical variables using small intervals on the measurement scale of the variable (for example, intervals of 5% of the working time spent with the trunk in a minimum of 30° of flexion) to determine whether there was a linear relation with low back pain. Those variables that showed a nonlinear relation with low back pain were divided into categories for further analysis. In general, small categories with similar relative risks were regrouped into a few larger categories, resulting in a division into three to five categories for most variables. Consistency of the categorization of related variables also was taken into account.

The presence of confounding was assessed by means of multivariable analyses. To prevent the occurrence of collinearity, the degree of interrelationship of the various risk factors selected for the multivariable analyses was checked. The Cox regression procedure in the SPSS computer package (Version 6.1.3), with a constant risk-period for all subjects, was applied for the estimation of adjusted relative risks.[16,21,22] Stepwise, the individual factors, psychosocial work characteristics, physical factors during leisure time, and physical factors at work that were selected on the basis of the results of the univariate analyses were added to a model that included only one of the work-related physical factors being studied at a time. To determine whether adjustment for the potential confounders influenced the results, it was checked whether the effect estimates for flexion and rotation of the trunk and lifting at work differed by more than 10% from the crude effect estimates.

The analyses were repeated for those workers who reported that no or only minor changes in their work had occurred during the first and second follow-up periods. This selection reduced the likelihood of misclassification of exposure resulting from changes in the physical work environment with time. Workers whose work had changed because of back pain also were included in these analyses because the exclusion of these workers could result in a false decrease in the effect estimates. Moreover, to determine the presence or absence of a healthy worker effect, the analyses also were repeated for those workers

Table 1. Crude Relation of Flexion and Rotation of the Trunk and Lifting at Work With Low Back Pain

Risk Factor	LBP	No LBP	Crude RR (95% CI) (n = 835*)
Percentage of the working time trunk flexion ≥ 30°			
≤ 5% working time	107	319	1.00
5–10% working time	46	134	1.02 (0.75–1.37)
> 10% working time	70	159	1.22 (0.94–1.57)
Percentage of the working time trunk flexion			
≤ 5% working time ≥ 30°	107	319	1.00
5–10% working time ≥ 30°	46	134	1.02 (0.75–1.37)
> 10% working time ≥ 30° and ≤ 5% working time ≥ 60°	49	123	1.13 (0.85–1.51)
> 5% working time ≥ 60°	21	36	1.47 (1.01–2.14)
Percentage of the working time trunk rotation ≥ 30°			
≤ 5% working time	145	422	1.00
5–10% working time	59	151	1.10 (0.85–1.42)
> 10% working time	19	39	1.28 (0.86–1.90)
Number of lifts per 8-hour working day			
Never	61	172	1.00
Never ≥ 10 kg/working day	38	104	1.02 (0.72–1.45)
Never ≥ 25 kg/working day	67	201	0.95 (0.71–1.29)
1–15 times ≥ 25 kg/working day	33	102	0.93 (0.65–1.35)
> 15 times ≥ 25 kg/working day	24	33	1.61 (1.11–2.34)
Number of lifts ≥ 25 kg per 8-hour working day			
Never	166	477	1.00
1–15 times/working day	33	102	0.95 (0.68–1.31)
> 15 times/working day	24	33	1.63 (1.17–2.27)

LBP = low back pain; RR = relative risk; CI = confidence interval.
* For 835 of the 861 workers, data were available on exposure to flexion and rotation of the trunk and lifting at work.

who had been employed in their current job for 5 years or fewer at baseline.

■ Results

From the cohort of 1192 workers, data on the occurrence of low back pain were available for 861 workers (72%) for all three annual follow-up measurements. Approximately 30% of the workers in this group were women. The mean age of the workers was 36 years, with an age-range of 18–59 years.

Crude Relations

The cumulative incidence of low back pain during the 3-year follow-up period was 26.6% in the total group and 24.7% and 30.8% in men and women, respectively. For 835 workers, data on exposure to flexion and rotation of the trunk and lifting at work was available from video-based observations. Table 1 presents the results of the univariate analyses.

Both trunk flexion and lifting at work were statistically significantly associated with the occurrence of low back pain. The relation between working with the trunk in a minimum of 60° of flexion and low back pain was stronger than the relation between working with the trunk in a minimum of 30° of flexion and low back pain. The relative risk for working with the trunk in a minimum of 30° of flexion did not increase with increasing duration of exposure. A slight increase in risk was found with increasing exposure to trunk rotation, but this relation was not statistically significant. Because of the small number of workers who spent more than 10% of their working time with the trunk in a minimum of 60° of flexion, or more than 15% of their working time with the trunk in rotation, it was not possible to determine whether there was a further increased risk at greater levels of exposure.

Lifting loads of less than 25 kg was not associated with an increased risk of low back pain. The risk of low back pain started to increase when a load of 25 kg or more was lifted more than 15 times per 8-hour working day. Further division of the highest exposure category of lifting showed a relative risk of 1.57 (95% CI 1.04–2.37) for lifting 25 kg or more 15–25 times per 8-hour working day and 1.74 (95% CI 1.06–2.88) for lifting a load of at least 25 kilograms more than 25 times per 8-hour working day, each compared with never lifting such a load.

Potential Confounders of the Studied Relations

Univariate analyses of the potential confounders showed that gender, exercise behavior during leisure time, high quantitative job demands, low supervisor support, low coworker support, moving heavy loads during leisure time, frequent flexion and rotation of the upper part of the body during leisure time, and driving a vehicle during leisure time and at work were univariately associated with low back pain with a P value of less than 0.25. Therefore, these variables were included in the multivariable analyses of flexion and rotation of the trunk and lifting at work. It was predetermined to include age, independent of its association with low back pain. Decision authority and skill discretion were included because it was considered wise to include all related variables of psychosocial work characteristics. Although working in a sitting position for more than 95% of the working time was associated with low back pain, with a P value of less than 0.25, this variable was not included in the multivariable analyses because the percentage of the working time spent in a sitting position had a very strong negative correlation with lifting at work ($r = -0.76$). Moreover, the effects of flexion and rotation of the trunk and lifting at work were not adjusted for each other because the interrelationship between these exposures was very high in the study population. Correlation coefficients in the region of 0.60 and greater were found for the relation between these three physical factors (data not shown).

The multivariable analyses of flexion and rotation of the trunk and lifting showed that adjustment for the selected variables did not influence the relative risks for the physical factors at work by more than 10% (Table 2). The confidence intervals of the relative risks estimated in multivariable analyses (Table 2) were wider than those of the relative risks resulting from univariate analyses (Table 1). This is because of the use of Cox regression, which produces adequate point estimates of the relative

Table 2. Results From Multivariable Analyses for the Relation of Flexion and Rotation of the Trunk and Lifting at Work With Low Back Pain

Risk Factor	Crude RR (95% CI)* (n = 780)	Adjusted RR (95% CI)† (n = 780)
Percentage of the working time trunk flexion ≥ 30°		
≤ 5% working time	1.00	1.00
5–10% working time	0.98 (0.68–1.41)	1.04 (0.70–1.54)
> 10% working time	1.17 (0.86–1.59)	1.19 (0.86–1.65)
Percentage of the working time trunk flexion		
≤ 5% working time ≥ 30°	1.00	1.00
5–10% working time ≥ 30°	0.98 (0.68–1.41)	1.05 (0.71–1.54)
> 10% working time ≥ 30° and ≤ 5% working time ≥ 60°	1.08 (0.77–1.53)	1.09 (0.76–1.58)
> 5% working time ≥ 60°	1.42 (0.88–2.30)	1.48 (0.90–2.42)
Percentage of the working time trunk rotation ≥ 30°		
≤ 5% working time	1.00	1.00
5–10% working time	1.10 (0.81–1.50)	1.08 (0.78–1.50)
> 10% working time	1.26 (0.77–2.06)	1.29 (0.77–2.15)
Number of lifts per 8-hour working day		
Never	1.00	1.00
Never ≥ 10 kg/working day	1.01 (0.66–1.53)	0.92 (0.60–1.42)
Never ≥ 25 kg/working day	0.95 (0.67–1.36)	0.98 (0.67–1.42)
1–15 times ≥ 25 kg/working day	0.87 (0.56–1.35)	0.83 (0.52–1.33)
> 15 times ≥ 25 kg/working day	1.59 (0.98–2.60)	1.57 (0.90–2.75)
Number of lifts ≥ 25 kg per 8-hour working day		
Never	1.00	1.00
1–15 times/working day	0.88 (0.60–1.31)	0.86 (0.57–1.30)
> 15 times/working day	1.62 (1.04–2.53)	1.62 (0.97–2.69)

RR = relative risk; CI = confidence interval.
* Crude relative risk from Cox regression in the population with no missing values for gender, age, exercise behavior during leisure time, quantitative job demands, decision authority, skill discretion, supervisor support, coworker support, moving of heavy loads during leisure time, flexion and/or rotation of the upper part of the body during leisure time, driving a vehicle during leisure time, and driving a vehicle at work.
†Relative risk from Cox regression, adjusted for the risk factors mentioned above.

risk, but too conservative estimates of the confidence intervals.[21,22]

Change of Work

Of the total group of 835 workers for whom complete data on flexion and rotation of the trunk and lifting at work was obtained from video-based observations, 724 (87%) workers reported that no or only minor changes in their work had occurred or that the change in their work reported at the first or second follow-up measurement was related to back pain. In this subgroup, the effect estimates for the physical factors that were studied were somewhat higher, especially for trunk rotation, but the pattern of the relations found remained the same (Table 3).

Healthy Worker Effect

At baseline, 360 workers (43%) reported that they had been working in their current job for 5 years or fewer. The effect estimates for trunk rotation and lifting at work were somewhat greater in this subgroup than in the complete cohort, but the pattern of the relations found remained the same for these variables (Table 3). For trunk flexion, the effect estimate for a minimum of 60° of trunk flexion did not increase, but an increase in the effect estimate was observed for a minimum of 30° of trunk flexion.

■ Discussion

Summary of Findings

All exposures in this study showed a moderately strong relation with the occurrence of low back pain. The degree of trunk flexion appeared to be a risk factor for low back pain. Extreme trunk flexion led to an increased risk of low back pain when the trunk was in a minimum of 60° of flexion for more than 5% of the working time. The weight of a load also appeared to be a risk factor for low back pain. Lifting 25 kg or more increased the risk of low back pain when this occurred more than 15 times per working day, and a slight increase in risk was observed with a further increase in the frequency of lifting. In the initial analyses, the relation of trunk rotation with low back pain was not so clear, but in the additional analyses, which included only those workers with no or only minor changes in their work during the follow-up period, all relations became somewhat stronger, and in the group of workers with the trunk in rotation for more than 10% of the working time, there was a definite increase in the risk of low back pain.

An important source of potential bias in occupational cohort studies is the healthy worker effect.[7] To minimize this form of bias, it would be better to study newly employed workers, but this was beyond the scope of the present study. An additional analysis of the group of workers who had been employed in their current job for 5 years or fewer, however, showed stronger associations with low back pain for the exposures under study, which indicates the presence of a healthy worker effect in the complete cohort.

Methodologic Strengths

The prospective design of the study made it possible to establish the existence of a temporal relation, which is a necessary criterion for causality.[19] The physical load at the workplace was assessed on the basis of observations. Although, for reasons of efficiency, these measurements were not made at the individual level, they were made on a large scale.[5] Adjustments for individual factors, psychosocial work characteristics, and physical factors during leisure time were made in the analyses. The history of back pain, a variable that has been shown to be an important predictor of new episodes of low back pain, was not included in the analyses reported here.[8] In the population of this study that had no low back pain in the previous 12 months at baseline, 65.4% of the workers reported ever having had low back pain at baseline, and this variable also was strongly associated with the occurrence of low back pain during the follow-up period (crude RR 2.74). It was decided not to adjust for a history of low back pain because prior low back pain also may be a result of the exposures under study, and there-

Table 3. Relation of Flexion and Rotation of the Trunk and Lifting at Work With Low Back Pain: Results of Subgroup Analyses

Risk Factor	Workers With No or Only Minor Changes in Work (n = 724) Crude RR (95% CI)	Workers Employed for 5 Years or Fewer in the Current Job at Baseline (n = 360) Crude RR (95% CI)
Percentage of the working time trunk flexion		
≤ 5% working time ≥ 30°	1.00	1.00
5–10% working time ≥ 30°	1.10 (0.80–1.52)	0.98 (0.61–1.57)
> 10% working time ≥ 30° and ≤ 5% working time ≥ 60°	1.20 (0.87–1.63)	1.53 (1.03–2.30)
> 5% working time ≥ 60°	1.72 (1.16–2.57)	1.55 (0.85–2.80)
Percentage of the working time trunk rotation ≥ 30°		
≤ 5% working time	1.00	1.00
5–10% working time	1.15 (0.87–1.52)	1.29 (0.89–1.87)
> 10% working time	1.57 (1.06–2.32)	1.75 (1.03–2.96)
Number of lifts per 8-hour working day		
Never	1.00	1.00
Never ≥ 10 kg/working day	0.91 (0.62–1.35)	0.82 (0.45–1.49)
Never ≥ 25 kg/working day	0.99 (0.72–1.36)	0.94 (0.59–1.49)
1–15 times ≥ 25 kg/working day	0.85 (0.57–1.28)	1.07 (0.64–1.80)
> 15 times ≥ 25 kg/working day	1.79 (1.22–2.63)	1.98 (1.16–3.39)

RR = relative risk; CI = confidence interval.

fore possibly an intermediate variable.[20] Additional adjustment for prior low back pain, however, appeared to have little or no influence on the effect estimates for the exposures under study (data not shown).

Limitations and Potential Sources of Bias

The possibility of bias because of loss to follow-up exists in any cohort study. In the present study, the exposure to work-related physical factors was greater in those workers who were lost to follow-up. This probably is related to the fact that this group had a relatively low level of education. It is not possible to determine whether these differences have influenced the results of the analyses, because the relation of exposure to work-related physical factors with the 3-year cumulative incidence of low back pain in the workers who were lost to follow-up is unknown. The incidence of low back pain at the first follow-up evaluation, however, did not differ for those workers who were lost to follow-up after this specific measurement (data not shown).

In the present study, it was possible to identify a minimum level of exposure to flexion and rotation of the trunk and lifting at work above which the risk of low back pain started to increase. Because of the relatively small number of workers with exposure above this level, however, it was not possible to study the further course of the relation of work-related physical exposures with low back pain at greater levels. Further, because of the strong correlation between flexion and rotation of the trunk and lifting at work in the study population, the independent causal effects of these exposures could not be separated.

Comparison With Previous Findings

Of special interest is comparison of the results of the present study with the results of the case-referent studies of Punnett et al[18] and Norman et al,[17] in which an observational method also was used to quantify the physical load at work. The present study confirms the finding of Punnett et al[18] that flexion and rotation of the trunk as well as lifting at work are risk factors for low back pain. Further, Punnett et al[18] also found that the risk increased with the degree of flexion. In their study, however, an exposure–response relation with low back pain was found for both mild and severe flexion, and their effect estimates for flexion and rotation of the trunk were greater than those of the present study, even though lower cutoff points were used for the definition of mild flexion (21–45°), severe (extreme) flexion (>45°) and trunk rotation (>20°). Punnett et al[18] found an odds ratio of 2.2 for the effect of lifting a load of at least 10 pounds (4.54 kg) at least once per minute throughout the working day, which is equivalent to at least 480 times per 8-hour working day. In the present study, an effect of lifting was found only for heavier loads.

In the study of Norman et al,[17] both trunk kinematic variables and external forces on the hands were associated with the risk of reporting low back pain at work. Crude odds ratios ranging from 1.4–2.4 were found. Unlike the study of Punnett et al,[18] the study of Norman et al[17] did include the assessment of possible psychosocial risk factors, but the analyses in the report of Norman et al[17] focused on the biomechanical data of the study and did not include the psychosocial risk factors. In addition, no attempt was made to examine exposure–response relations.

Comparison of the results of the present study with the results of the Boeing study is difficult, because in the Boeing study two different measures of heavy physical work were studied that did not resemble the operationalizations of physical load at work in the present study.[3,4] No statistically significant association was found between these measures of heavy physical work and reports of back pain.

When the results of the present study are compared with the results of previous prospective cohort studies on risk factors for low back pain, one has to be aware that relative risks were computed in the present study, whereas most previous cohort studies computed odds ratios using logistic regression. In the case of an outcome measure with a relatively high occurrence, such as low back pain (26.6% in the present study), odds ratios are overestimations of the relative risk.[16,21,22] For example, for lifting loads of at least 25 kg more than 15 times per working day, the present study found a relative risk of 1.6. If one estimates an odds ratio based on the same data, one finds an effect estimate of 2.1.

■ Conclusions

This is the first prospective cohort study that has been carried out to investigate the relation between flexion and rotation of the trunk and lifting at work and the occurrence of low back pain, in which the work-related physical factors were actually measured. In addition, individual factors, psychosocial work characteristics, and other physical factors were taken into account as potential confounders. The main conclusion that can be drawn from this study is that flexion and rotation of the trunk and lifting at work are moderate risk factors for low back pain. Extreme trunk flexion and lifting loads of 25 kg or more seem to be especially important.

■ Key Points

- In this 3-year prospective cohort study of work-related physical risk factors for low back pain, the physical load at work was quantified, and adjustments were made for individual factors and psychosocial work characteristics.
- The 3-year cumulative incidence of low back pain was 26.6%.
- Flexion and rotation of the trunk and lifting at work are moderate risk factors for low back pain, especially at greater levels of exposure. A moderately increased risk of low back pain was observed for workers who worked with the trunk in a minimum of 60° of flexion for more than 5% of the working time, for workers who worked with the trunk in a minimum of 30° of rotation for more than 10% of the working time, and for workers who lifted a load of at least 25 kg more than 15 times per working day.

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